Conclusions and Perspectives

Key Observations Arising from Papers on Sustainable Production, Use and Recycling of Natural Resources

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The intent of the papers in this Special Issue is to begin to learn about tools and measures to enhance sustainable production, use and recycling of natural resources. A life cycle perspective is taken as starting point, investigating the influence of drivers along the whole production-use-recycling-waste management chains. The resources sectors include 1) agriculture, 2) metals, 3) forest products and 4) fisheries. These papers focus on experiences obtained in different disciplines and in the use of the approaches that are applied. Sectors along full life cycles are addressed, including resource extraction, manufacturing, and recycling activities. This paper summarizes key observations, findings and discussions from the articles published in this issue.

Social Sustainability & Process Industries

Carin Labuchange and Alan C. Brent. Social Indicators for Sustainable Project and Technology Life Cycle Management in the Process Industry. Through the use of two case studies, one a chemical facility and the other an open cast mine, an approach to calculate Social Impact Indicators is presented. The feasibility of such an approach is examined. Difficulty with availability of data and information and the number of possible indicators is discussed. Within the paper is an excellent summary of the various social criteria that are addressed by the current frameworks and guidelines is presented. Options on how best to proceed with the further development of social LCA methodologies are outlined.

Agriculture

Leda Coltro, Anna Lúcia Mourad, Paula A.P.L.V. Oliveira, José Paulo O.A. Baddini and Rojane M. Kletecke. Environmental Profile of Brazilian Green Coffee. The authors present an LCA study of coffee for Brazil, the biggest producer worldwide with 30% market share. he study shows important results for a better correlation of agricultural practices and potential environmental impacts related to it. On this basis, it gives clear recommendations on different agricultural practices that produce different environmental performances. These important results must be brought into practice.

Geert R. de Snoo. Benchmarking the Environmental Performances of Farms. The paper points out to market-oriented instruments that contain inflexible prescriptive requirements, such as banning certain pesticides, or limits to their application. The author suggests that this has led to farmer's being classified as 'in' or 'out' of the system stifling further improvement of best practices. An alternative approach to certification is presented based on a relative measure of best performers, for example, certification of only the best 50% of the farmers based on a benchmarking assessment of the participants. It is encouraged to further document the success of the program, e.g., observed improvements made in sustainable farming practices by farmers as a result of the pilot study. Additionally comparison to other existing benchmarking programs (e.g., KUL/USL in Germany) assessing differences, strengths or weaknesses would be useful for potential users of the approach.

Metals

Thomas P. Gloria, Andrea J. Russell, John Atherton, Scott R. Baker and Murray Cook. Ecological Toxicity Methods and Metals. An examination of two case studies. In two case studies, one on a Cu-based product and one on a Zn-based product, it appears that at present some convergence is taking place in characterization factors for these metals between 5 leading LCIA methodologies. This is in line with the concerns included in the Apeldoorn Declaration on toxicity modeling of metals, established during a stakeholder workshop. At present, LCIA results of the different characterization models for metals are not sufficiently reliable for decision making and cannot be used as the only source of environmental information. A promising outlook is indicated for the solution of the present state of affairs, particularly related to the work of the UNEP/SETAC Life Cycle Initiative. Here lies an important point for discussion, as other experts in the field argue that studies like the present one show that world-wide recommended practice on metals toxicity modeling may still be a few years away. The ability of researcher to solve quickly some of these methodological issues will be a topic of continued debate. In any case we should continue to conduct LCA studies with an understanding of the strengths and limitations of the methodology.

Kenneth J. Martchek: Modelling More Sustainable Aluminium. The author models aluminum flows in the economy and examines the size of different flows, and consequences of different strategies (assessment of markets, system losses, recycling rates, selected resource requirements, air emissions; policy implications thereof). Discussion is presented on ways to improve the environmental management within companies by focusing on energy and climate change. For example, by a better understanding of the post-consumer recycling rates and of the metallurgical yield by products to produce aluminum (or the losses to the environment by products), they can make a better contribution to the positive impact of enhanced recycling.

Troy Hawkins, H. Scott Matthews and Chris Hendrickson: Closing the Loop on Cadmium: An assessment of the material cycle of cadmium in the USA. In the present study, the

flows and storages of cadmium are investigated. The authors use an input-output model which appears to be Substance Flow Analysis, although it is not called that. Special attention is given to co-production of cadmium with zinc. Recommendations relate to controlling, not forbidding cadmium, as to use in long-lived products, easily collected and recycled. Additional work may imply to investigate the risks connected with the storages and emissions of cadmium. Further, the study leaves the question unanswered what finally should be done with cadmium, as recycling together with a continued inflow in the economy will lead to an ever increasing accumulation. In particular, the study is interesting as it shows that an SFA approach clearly answers questions which are quite different from the questions answered by LCA.

Forest Products – Furniture

Annik Magerholm Fet and Christofer Skaar. Eco-labeling, Product Category Rules and Certification Procedures Based on ISO 14025 Requirements. This paper gives insight in the detailed steps required and challenges encountered to produce EPDs based on life cycle information. It is a valuable contribution to the LCA community and a much needed real-world example of precisely how LCA is being used to support information for the purposes of influencing business-to-businesses and consumer purchasing decision-making.

Fisheries

Rattanawan T. Mungkung, Helias A. Udo de Haes and Roland Clift: Potentials and Limitations of Life Cycle Assessment in Setting Ecolabelling Criteria: A case study of Thai shrimp aquaculture product. The paper illustrates how LCA can be used as the basis for ecolabelling criteria for shrimp aquaculture in Thailand, a typical product intended for export from a developing country. The results of the LCA study conclude that farming is the key life-cycle stage generating the most significant environmental impacts, including abiotic depletion and global warming are readily quantifiable and easily covered by quantitative ecolabelling criteria. In the light of ISO 14024, *Environmental labels and declarations – Environmental labeling Type I – Guiding principles and procedures,* the main limitations and barriers associated with the application of LCA to setting ecolabelling criteria particularly in developing countries are discussed, including recommendations on how to overcome them.

Harald Ellingsen and Svein Aanond Aanondsen. Environmental Impacts of Wild Caught Cod and Farmed Salmon: The authors attempt to compare the fish products to chicken, but this step is a difficult one where additional work is necessary, particularly related to ensure comparable system boundaries among the systems studied. The study should be viewed as a solid step towards developing a methodology for comparative LCA studies for food products.

Mikkel Thrane: LCA of Danish Fish Products: New methods and insights. The study focuses on the usual LCIA impact categories, not including land use (in this case sea floor use) and by-catch. It is argued however, that energy intensity can be used as overall impact measure, also indicative for impacts outside the usual LCA scope, like damage to the sea floor and by-catch of fish and mammals. Using this indicator, the study also shows that impact reduction up to a factor 15 can be obtained by changing to other fishing techniques. These important results must be brought into practice. It will be interesting is how this link to practice will and can be established. From a research perspective, the paper illustrates the value of examining a variety of allocation methods and interpreting the results in light of each of them.

Summary and Overall Recommendations

In this issue, a number of papers advance the knowledge of the application of life cycle approaches to management of the production, use and recycling of natural resources. This is just the start. Considerable research and application are still necessary to explore the validity and usefulness of the different approaches for resource management. One direction is the use of quantitative analytical tools like life cycle assessment, comparative risk assessment, and substance flow analysis, modelling environmental impacts along the life cycle of materials and products. Another approach is a focus on the certification of resource extraction, possibly supported by the use of quantitative models. Overall recommendations from this issue include:

1. Information sharing on case studies and approaches to use LCA and other approaches in management of natural resources should be pursued. The further development of the idea of a library within the UNEP/SETAC Life Cycle Initiative may be one approach to capture this information for sharing.
2. More insights are needed on which impacts and risks that can be included in quantitative life cycle approaches that are relevant on the global level, and the ones that may be analyzed using threshold type approaches (using 'hurdle criteria').
3. International research collaboration is necessary to include biodiversity impacts like those on forests and on the marine environment, and the depletion of wood and fish stocks into the standard impact categories of life cycle approaches.
4. Relationships among supply chain organizations that cut across the developed and developing countries ask for specific attention.
5. Another approach concerns the establishment of alliances between key players along the value chain of production, use and recycling of natural resources, particularly where small and medium size enterprises (SME) from developing countries are involved.
6. Promotion of the life cycle approach to those unfamiliar with it, and capacity building at various educations levels in both developed and developing countries are crucial elements to come to a level where decisions are taken with life cycle thinking in mind.
7. Strengthening the reach out to resource management organizations (e.g., fisheries societies) to explore new application patterns of life cycle thinking and to broaden the use of life cycle tools will result in improved information for decision making.
8. The ultimate driver for providing life cycle information can be the consumer, but can also be upstream companies and governments who want to improve their societal image; the type if information which is needed will be quite different for the different situations.